EXHIBIT G

White Paper

Business benefits of WCDMA technology

NOKIA
CONNECTING PEOPLE

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Introduction

New and increasingly advanced data services are driving up traffic, which is being further boosted by growth in voice in advanced markets as the migration from fixed to mobile continues. Meanwhile, difficult trading conditions have caused a number of operators to delay making substantial investments in upgrading their networks to higher capacity. In today's commercially challenging climate, all capital investments must be well justified. This is already putting pressure on some networks and may be leading to difficulties in maintaining acceptable levels of service to subscribers.
This white paper focuses on business related benefits that WCDMA is bringing to the mobile environment as the most efficient service enabling technology in the medium to long run that can fill operators' need for cost-effective capacity.

Executive summary

For those operators with IMT-2000, or UMTS licences, WCDMA technology is economically viable because it provides the most cost-effective means of adding significant capacity for both voice and data services. Although some investment is needed in a new radio access network, there is a worthwhile return in the form of much higher capacity to cope with today's voice and data needs, as well as future data-intensive services. Furthermore, as subscribers gradually migrate to WCDMA, existing resources in the GSM layer will be freed up, thus relieving the pressure for new 2G investment, which is substantially less cost-effective, particularly for data services.

In addition, the high bandwidth and low latency of WCDMA contributes significantly to a high-quality user experience that can make a crucial contribution to the revenue gained by operators. WCDMA will also provide the fast access that users will demand as they start to take up more advanced data services. Investing in WCDMA today gives operators an early opportunity to meet these demands and maximise their profit potential, build their image as a state-of-the-art operator, achieve high ARPU and build greater subscriber loyalty.

Nokia estimates that, depending on the coverage required, the capital cost of upgrading an existing GSM/GPRS network to WCDMA is between 10 and 40% of the initial cost of building a GSM 1800 MHz network with about the same site density as the WCDMA network. Once the initial rollout investment has been made, building additional WCDMA capacity is relatively cheap, costing less than half the price of an equal voice capacity expansion in a GSM network.

That there is growing demand for new mobile data services has been shown by the increase in data traffic and data ARPU experienced by operators. Subscribers appreciate high quality connections and highly advanced terminals and will naturally want to adopt WCDMA.

New features being added to the mobile service network will soon bring advanced methods for charging for service content and migrating subscribers to WCDMA. These will enable operators to charge for the real value of services to individual users, with different prices being applied for different types and quality of services. This capability will help operators to maintain profitability by using more sophisticated strategies when launching services.

Forthcoming upgrades of WCDMA technology, High Speed Downlink Packet Access (HSDPA) and High Speed Uplink Packet Access (HSUPA), will boost a network's capacity and data speed considerably and help to ensure that any investments made in WCDMA today will be giving returns for many years to come.

Traffic in mobile networks is growing

Operators are facing an investment dilemma. Today's tough economic conditions demand that only the most vital of investments be made and that even these face the closest scrutiny to ensure that they can be fully justified.

Consequently, the level of investment in network infrastructure has been reduced by many operators in a bid to protect profitability. Yet operators face strong pressure to raise spending on the network to maintain a competitive position.

A major source for this pressure comes from the continuing growth in network traffic. As far back as November 2002, analyst Goldman Sachs estimated that network traffic had increased by more than 60% over the previous two years, yet network spend in 2002 had decreased by nearly 20%.

Although voice commands a declining share of overall mobile spending, the volume of voice traffic and the total voice revenue are still increasing as the number of subscribers grows and as the shift from fixed to mobile voice picks up. Nokia estimates that by 2007, mobile traffic will have grown by 172%, accounting for about half of the total traffic in telephone networks.

This migration is a clear opportunity for operators to increase revenue, because mobile subscribers tend to spend more than fixed subscribers. According to a study made by Strategy Partners in 2002, mobile subscribers typically generate 40% of telecommunications revenue despite generating just 20% of the total traffic.

The opportunities provided by fixed-to-wireless migration have been recognised by operators, too. Spain's Telefonica Moviles has stated that fixed-to-mobile substitution, along with mobile data services, "will drive significant growth in MOU (Minutes of Usage) and revenues in Spain". (June 2003, Credit Suisse First Boston quote in Global Mobile Daily).

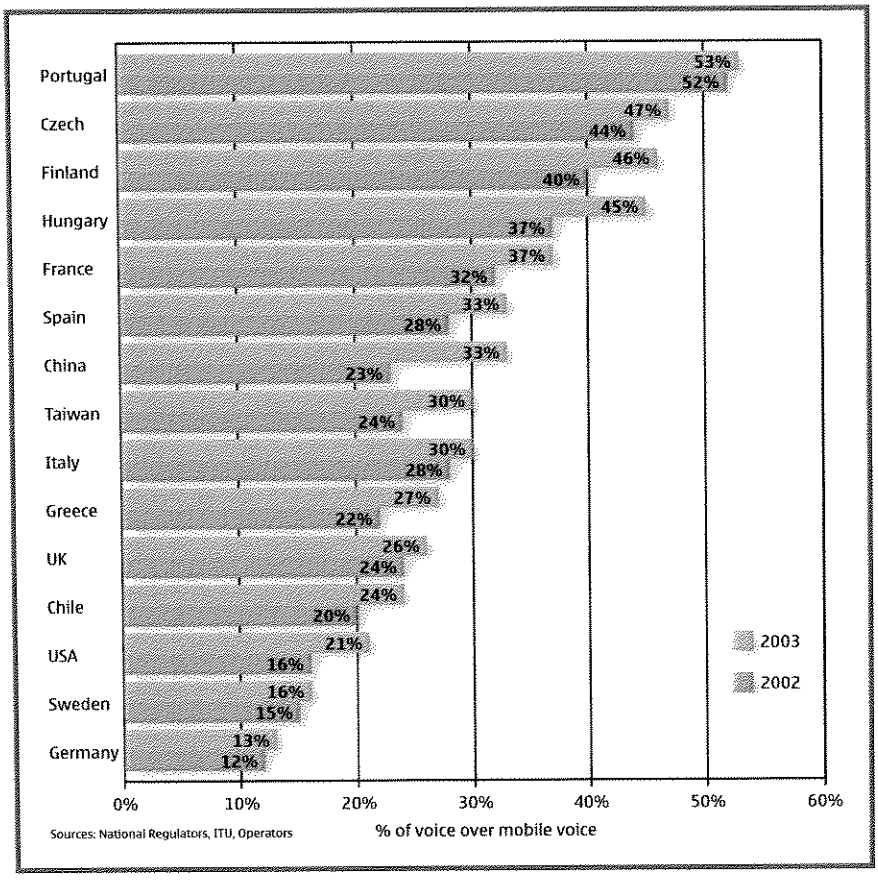

Figure 1. Proportion of mobile traffic of all telephone traffic in various countries

The rapid rise in MMS and content download services has also increased traffic. The amount of extra traffic that these services can generate is relatively high. For example, suppose a typical subscriber generates 200 minutes of voice a month (equivalent to 18.3 MB). If this same user then sends 19 photo MMSs and 10 video MMSs (typically 40 kB and 100 kB respectively) each month, about 10% extra traffic is created. When the user also downloads 20 audio files, 30 video clips and watches streaming video for 15 minutes each month, 78% extra traffic is generated. In the coming years, the availability and take-up of more advanced services will continue to drive up traffic.

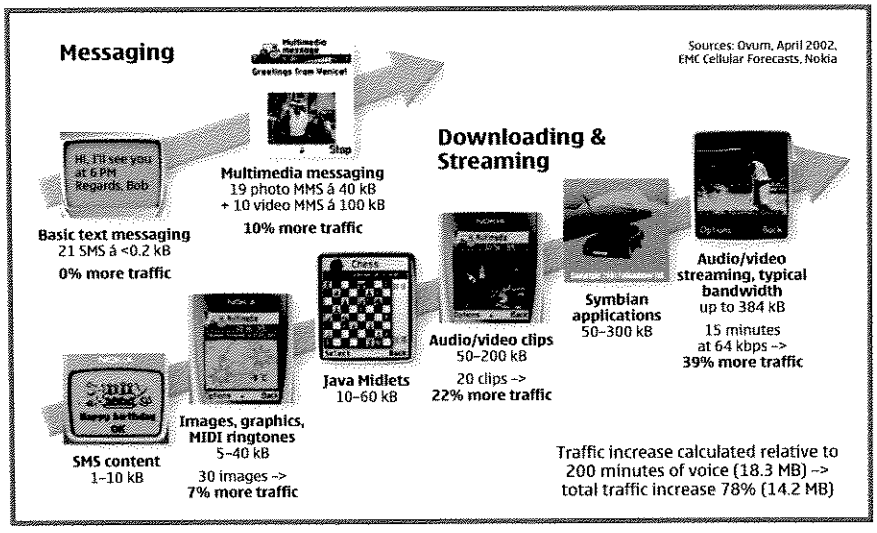

Figure 2. How services and more advanced content is demanding greater capacity

Such data services are valuable to operators because it has been shown that relatively simple services, such as picture messaging, can contribute significantly to increased ARPU. Subscribers of Norwegian mobile phone operator Telenor Mobil sent a total of 11 million MMS messages in the second quarter of 2004, up from 3.4 million in the first quarter of 2004. MMS is especially popular among younger subscribers according to Telenor Mobil (Telenor and Norwegian News Digests, July 2004). In Japan, NTT DoCoMo reported in its Financial results for the first quarter of 2004 that the data ARPU of its 3G subscribers has been consistently close to double the average data ARPU of all of its mobile subscribers.

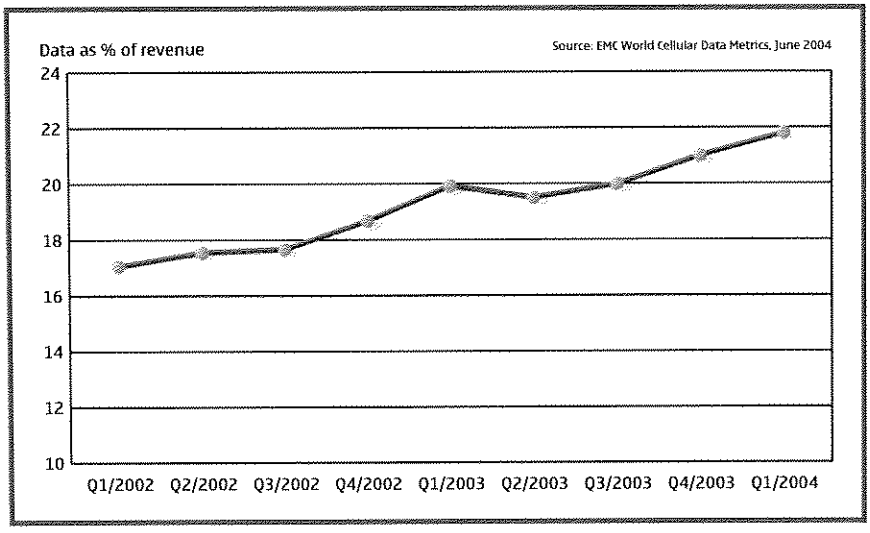

Figure 3. Increase of data as a percentage of all revenues for 20 leading operators in the world.

It is a similar story for other operators around the world who are finding that ARPU from data services is making up a steadily increasing proportion of their total ARPU. In June 2004, EMC reported that data related ARPU already averages 22% of total revenue for the 20 leading operators, having grown 2% per year between Q1 02 and Q1.

Importance of service quality

The continuous rise in traffic will shortly, if it does not already, pose new challenges in maintaining an acceptable quality of service. As the volume of traffic flow approaches the network's capacity, subscribers will experience longer response times for data services, poorer voice quality and an increase in the rate of dropped calls. Any problems that mobile subscribers experience with mobile connectivity are likely to increase churn.

Clumsy data connections may also slow the take-up of mobile data services in general and so diminish revenue from the most lucrative services in terms of ARPU. The higher bandwidth required by advanced services like video conferencing is further increasing the importance of quality as a key factor for network operators in defending and expanding market share and revenue.

The answer is to build more network capacity. The question that then arises is what is the most cost-effective investment for building this additional network capacity?

Migration to WCDMA means reduced total investment

For those operators holding UMTS licenses, building WCDMA infrastructure to boost capacity is the most cost-effective option in the medium to long term. The reason for this is simple – in addition to providing fast data access, WCDMA also brings extremely high capacity and efficiency in capacity usage for narrowband services, both voice and data.

It was the need for more voice capacity that drove Japan to be one of the first countries to start developing and implementing WCDMA, because the country's existing PDC (Personal Digital Cellular) networks could not serve the increasing capacity demands of mobile voice consumers.

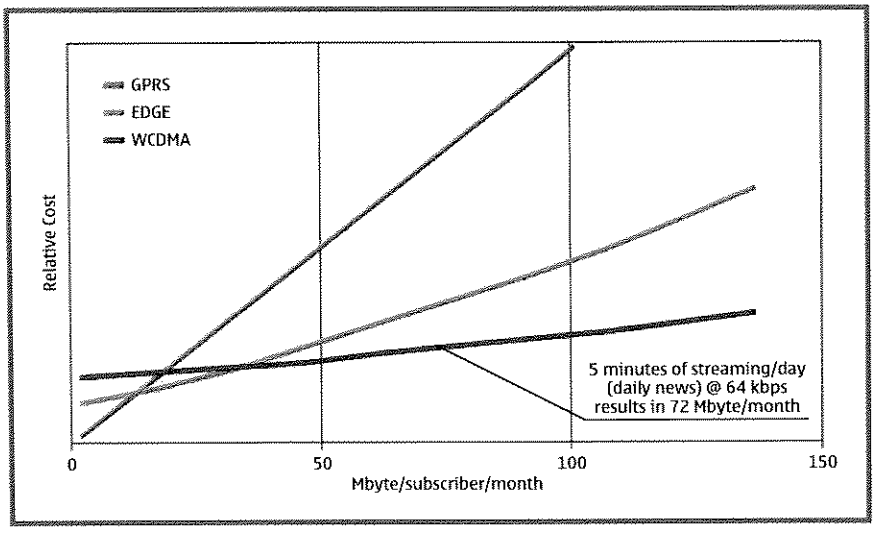

Figure 4. As users access and download more data, the relative capital cost of WCDMA becomes more attractive

For existing GSM operators, migrating a portion of their subscribers to WCDMA will reduce the cumulative investment needed for both the GSM and WCDMA access layer. Such migration will also help to ensure increased quality of service for GSM/GPRS users. With dual-mode GSM/WCDMA terminals already commercially available, efficient use of both GSM and WCDMA capacity can be ensured by implementing effective intersystem handovers within the network.

Upgrading an existing network to WCDMA

Nokia estimates that, depending on the coverage required, the capital cost of upgrading an existing GSM/GPRS network to WCDMA is between 10 and 40% of the initial cost of building a GSM 1800 MHz network with about the same site density as the WCDMA network. This is the most cost-effective way to achieve WCDMA coverage because much of the existing GSM infrastructure can be shared between GSM and WCDMA. With some systems the existing GSM core, service platforms and care and billing systems can be used for both networks. In the radio network, base station sites and site equipment, as well as the transmission network can also often be shared.

After the initial investment in network deployment, building additional WCDMA capacity is highly cost-effective compared with GSM/GPRS. According to Nokia's estimates for high-load conditions, which in practice are the basis for capacity planning and building, adding WCDMA capacity to an existing network costs less than half the price of an equal voice capacity expansion in a GSM network.

From the operator's point of view, this means that the delivery cost of a service grows at a relatively flat rate in relation to the size of the application. The role of bandwidth as a limiting factor diminishes radically, resulting in greater freedom in both services design and pricing strategies. Indeed, WCDMA allows operators to offer highly data-intensive services at competitive prices while still maintaining healthy margins.

One of the main reasons that the cost of WCDMA capacity is so attractive is the far better integration of RF components in the base station compared with any other radio or mobile technology. A WCDMA base station cabinet has several times the RF capacity of GSM cabinets.

One, often overlooked, capability of WCDMA technology is its flexibility in allocating capacity to offer the optimal quality of service for different traffic types. The capacity profile of a base station automatically adapts to meet the prevailing local demands, allowing capacity to be freely allocated between all types of services, whether voice or data.

WCDMA provides superior service quality

There is a major difference in the cost of delivery and the user experience that WCDMA provides over GSM/GPRS. The higher bit rate enables a WCDMA network to provide significantly better end-to-end performance, especially for medium-band and wideband data services. On the other hand, WCDMA's shorter round trip times – the time needed by the network to transfer one bit or data package to, for example, a server and back – accelerate delivery of all types of data services, with its effect being most tangible for narrowband data.

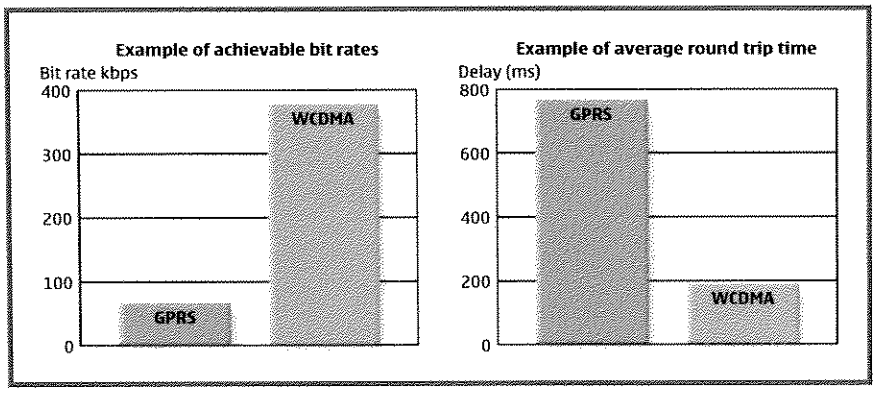

Figure 5. Higher bit rate and lower latency of WCDMA improves the user experience

A performance and usability study made by Nokia in a commercial test network in September 2002 backs up these values. The study was carried out by connecting a laptop computer to the Internet via a Nokia 6650 WCDMA terminal, and it showed that many business applications are actually more sensitive to delays in the network than to bandwidth. Due to its shorter round-trip times – a quarter of those experienced with GPRS – the WCDMA network clearly outperformed a GPRS connection.

In several cases, the WCDMA connection was so good that it came close to that of a LAN. For example, a widely used standard e-mail application worked very well for joint mail and calendar use, with delays of typically just a few seconds compared with LAN. Web browsing also worked well – the download times for an Internet newspaper were 2–3 seconds in a LAN environment and around 6 seconds over a WCDMA connection.

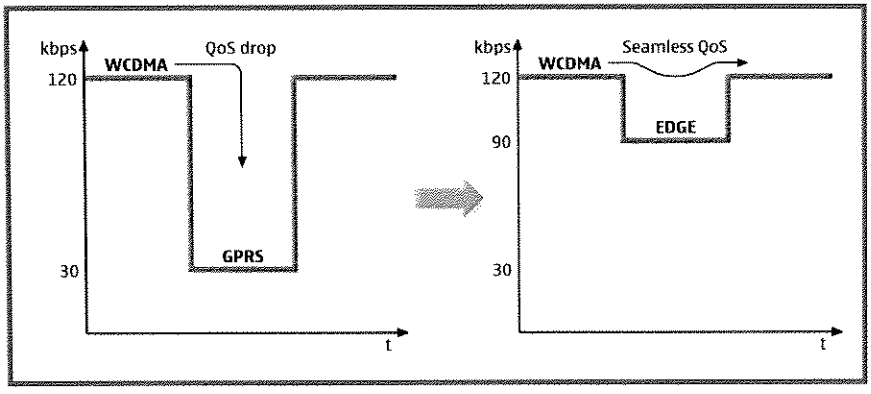

Figure 6. EDGE and WCDMA complement each other to give users a seamless experience even when moving out of WCDMA coverage. The drop in quality of service (QoS) when moving from WCDMA to GPRS is significant, whereas moving from WCDMA to EDGE coverage will cause much less of a drop in QoS which will be hardly noticeable to most users.

GSM/EDGE complements WCDMA coverage

The extent of WCDMA coverage also has an important influence on costs. As WCDMA is at its most cost-effective in areas where high capacity is needed, operators may decide to implement WCDMA in high traffic areas and leave the basic coverage to the existing GSM infrastructure.

Many operators have already chosen to upgrade GSM radio access to EDGE to boost capacity and maintain a high level of service. An additional benefit is to complement 3G coverage when a user moves out of range of the WCDMA network.

Nokia estimates that the cost of upgrading a GSM network to EDGE capability is relatively low at between 2% and 20% of the initial network cost, depending on how much new hardware is needed in the existing GSM/GPRS network for the EDGE coverage. In return, EDGE provides a three- to four-fold increase in the data speeds, enough to ensure good quality also for wideband data services.

Together, EDGE and WCDMA have far lower capital and operational costs per byte as users take up data services and consume more Mbytes per month (see Figure 4).

Early adopter segments and differentiating services already exist for WCDMA

Ensuring the successful launch of new data services is vital to growth. Already, data services are providing an increasing and significant proportion of global mobile services revenue.

Experience also shows that immediately a service is launched the initial take-up can be very rapid. There are many examples: China Mobile acquired more than 1 million MMS subscribers within two months of the launch of its MMS service. Vodafone reported that its Live! Service had won nearly two million subscribers within the first eight months. In Italy, 3 has reportedly signed up two million WCDMA customers in 20 months, since its commercial network launch in March 2003. And in Japan, NTT DoCoMo announced in May 2003 that the launch of an exciting new 3G terminal had helped to increase its WCDMA subscriber base by 177% to 421,000 in just three months. By the mid of December 2004, NTT DoCoMo had increased its subscriber base further to 7.8 million. In the mean time, the total number of WCDMA subscribers had reached 14.2 million globally, with approximately 1 million new users won every month during 2004.

With WCDMA, advanced services including multi-tasking (the use of multiple simultaneous connections for different services using a single terminal), video conferencing, high quality streaming and high-speed corporate data access will become feasible at competitive pricing. These services are particularly suited to high-end users who have the need for and the means of acquiring the latest and best technology to enhance their lifestyle and work productivity. They have the potential to bring operators substantial new revenue and help operators enhance their brand image effectively.

However, it is crucial to service take-up that subscribers find the service sufficiently easy and fast to access and use. With its superb performance for both narrowband and wideband services, deploying WCDMA coverage early helps operators build competitive advantage and market share through the high quality perceived by their subscribers.

WCDMA terminals are available now

WCDMA terminals have also reached commercial maturity. According to terminal manufacturers' public announcements, there are a total of 106 different WCDMA terminal models available today from all manufacturers (Source: GSA Dec 2004), and the majority of those are dual mode GSM/WCDMA terminals. To date, Nokia has four different WCDMA terminal models available, and approximately ten more will be announced during 2005.

To support combined WCDMA/EDGE deployment strategies, the first dual-mode WCDMA/EDGE terminal, Nokia 6630, is already available. Nokia, for example, has stated that EDGE support will be a standard feature in most of its WCDMA handsets from 2004 onwards.

Flexible charging to maximise profitability across all services

Developments within the GSM/GPRS/EDGE/WCDMA core network are already in place that will help operators achieve fast WCDMA adoption among subscribers and enhance profitability. While current methods enable charging based only on the volume of data transmitted, tools that enable more flexible pricing strategies are being implemented, enabling operators to price content according to its perceived value and not just the flat rate cost of delivery. Thin margins can be used on some services to attract subscribers, who will then be more willing to purchase more valuable content that has a bigger margin.

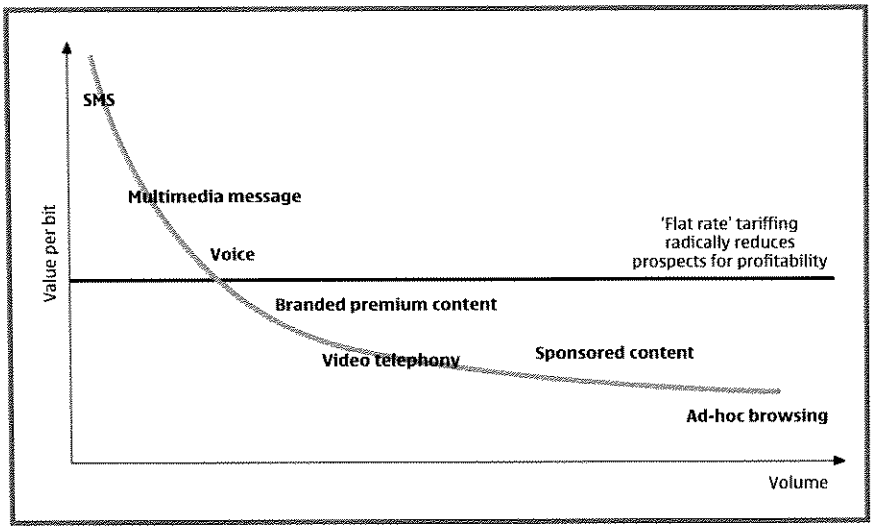

Figure 7. The perceived value of different services

Furthermore, users are often wary of new services because they do not know what the costs will be or what they are getting for their money. Subscribers are more likely to use services when they are aware of the costs and have a feeling of control over the services. Operators need to provide easy access to content services with easy to understand pricing that reflects the value of the services to the user. For more expensive services, the user will demand to be told the cost before accessing or downloading them.

Nokia calls this capability Intelligent Content Delivery (ICD) which requires the use of a service-aware network packet core that can differentiate between different content types and charge accordingly. With ICD, an operator could apply different traffic charging rules (€/kbit) based on the URL accessed via WAP or HTTP. As an example, an operator may provide a lower tariff or free access to a URL that demonstrates and promotes available games. When the user decides to actually play or download the game, a higher transmission fee can be applied when the download URL is accessed.

Charging may also be based on the access point used, the protocol used (such as HTTP, SMTP or IMAP) and the service or server as identified by domain name, IP address or subnet.

The flexibility of ICD enables an operator to differentiate between services for the mass market and for high-end customers, as well as building subscriber loyalty by taking advantage of diverse niche markets in which users would be willing to pay a substantial premium for specific services. Furthermore, operators are able to interface with independent service providers more efficiently in order to acquire third-party content and increase and diversify their service portfolio.

WCDMA will evolve to even higher speeds and capacity

The speed, capacity and cost-effectiveness of WCDMA can be enhanced in the future by the introduction of 3GPP-standardised HSDPA technology. Standing for High Speed Downlink Packet Access, HSDPA boosts WCDMA's downlink speed and offers typical bit rates up to 2Mbps, five times higher than is possible with current WCDMA implementations, with peak rates of up to 14.4 Mbps in a 5 MHz channel. In addition, base station capacity is doubled. With such high capacity, wideband services can be offered to the mass market at very affordable prices without cannibalizing profit.

HSDPA is based on WCDMA evolution, standardised as part of 3GPP Release 5 WCDMA specifications. The new modulation method of HSDPA greatly improves the peak data rate and throughput, which enhances spectral efficiency. In addition to these benefits, users will perceive faster connections to services through shorter round trip times.

A similar improvement is in the pipeline for enhancing WCDMA's uplink. Known as HSUPA (High Speed Uplink Packet Access), the new technology offers data rates that will theoretically peak at 5.8 Mbit/s. Standardization is already underway and is due for completion by March 2005 as a part of 3GPP Release 6.

Conclusion

It is clear that traffic in mobile networks is growing and will continue to rise as new data services are launched, as new subscribers are gained and as the continued migration from fixed to mobile pushes up voice traffic.

To avoid difficulties in maintaining acceptable levels of service to subscribers as network traffic rises, operators need to add capacity to their networks. For operators with IMT-2000, or UMTS licenses, WCDMA technology provides the most cost-effective means of adding capacity for both voice and data services.

Investing in WCDMA also enables operators to meet user demand for fast access as more advanced data services are taken up. With WCDMA, operators have a cost effective technology to help them maximise their profit potential, build their image as a state-of-the-art operator, achieve high ARPU and build greater subscriber loyalty.

Furthermore, as subscribers gradually migrate to WCDMA, existing resources in the GSM layer will become freed up, thus relieving pressure for new 2G investment.

WCDMA is also a standardized globally accepted technology with a defined evolution path. A development of WCDMA called HSDPA will boost capacity and data speed even further, helping to ensure that today's WCDMA investments will continue to provide significant returns for many years to come.

Glossary of terms and abbreviations

3GPP	Third Generation Partnership Project
EDGE	Enhanced Data Rates for Global Evolution
GPRS	General Packet Radio Service
HSDPA	High Speed Downlink Packet Access
HSUPA	High Speed Uplink Packet Access
ICD	Intelligent Content Delivery
MMS	Multimedia Messaging Service
PDC	Personal Digital Cellular
QoS	Quality of Service
RNC	Radio Network Controller
UMTS	Universal Mobile Telecommunications System
WAP	Wireless Access Protocol
WCDMA	Wideband Code Division Multiple Access

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Some of the statements in this document are forward-looking statements, including without limitation those regarding (i) estimates of the growth of mobile traffic, (ii) spending in mobile network infrastructure by operators, (iii) expected number and features of WCDMA terminals available in the future and (iv) HSDPA upgrade to WCDMA technology. Because these statements involve risks and uncertainties, actual results may differ materially from these forward-looking statements. For a discussion of the factors that could cause these differences, readers are directed to the risk factors specified on pages 21 to 23 of the Company's Form 20-F for the year ended December 31, 1999 and the factors listed in the final paragraph of the Company's press release dated March 15, 2001.

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HSDPA

HSDPA (High Speed Downlink Packet Access) marks a similar boost for WCDMA that EDGE does for GSM. It provides a two-fold increase in air interface capacity and a five-fold increase in data speeds in the downlink direction. HSDPA also shortens the round-trip time between the network and terminals and reduces variance in downlink transmission delay.

The improvements in performance are achieved by:

- bringing some key functions, such as scheduling of data packet transmission and processing of retransmissions (in case of transmission errors) into the base station - that is, closer to the air interface
- using a short frame length to further accelerate packet scheduling for transmission
- employing incremental redundancy for minimizing the air-interface load caused by retransmissions
- adopting a new transport channel type, known as High Speed Downlink Shared Channel (HS-DSCH) to facilitate air interface channel sharing between several users
- adapting the modulation scheme and coding according to the quality of the radio link.

Read more about HSDPA:
Nokia HSDPA Solution white paper (pdf file, 394 KB).

Read about Nokia WCDMA Solution.

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